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# THE PRESERVATION OF FISHING NETS

BY J. T. CUNNINGHAM, M.A.

LONDON
ADAM AND CHARLES BLACK
1902

# THE PRESERVATION OF FISHING NETS

MANGROVES.

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# THE PRESERVATION OF FISHING NETS:

## ITS SCIENCE AND PRACTICE

## CHAPTER I

### TANNING MATERIALS AND THE METHODS OF TESTING THEM

THE cotton and hemp of which nets, lines, and ropes are made consist of vegetable fibres, which, however strong they may be when new, become weakened by use and by exposure to air and water. They may lose their original strength in two ways—mechanically by wear and tear, chemically by rotting or decomposition, and unless means are taken to prevent it, the conditions to which the materials are exposed in fishing operations will cause them to become rotten long before they would be worn out mechanically.

The rotting or decomposing processes which take place in the materials of fishing gear, as in other vegetable and animal substances, are produced by the action of minute living particles of the nature of moulds, yeasts, or bacteria. Air and moisture are usually necessary to the life and development of these

agents, and, therefore, gear that is stored in a dry condition will suffer little or no harm even in its natural state. When in actual use, however, it is constantly exposed to air and water, and, therefore, preservative treatment is necessary to increase the durability of the materials by preventing the life and growth of putrefying organisms in them. At the same time, the treatment employed may serve to protect the materials from mechanical wear and tear.

Methods of preservation or 'curing' are most important in relation to the nets used in drift-fishing, both on account of the enormous scale on which such nets are used, and of the fact that they are generally made of cotton, a material which, in its natural condition, has but little durability under the conditions of drift-net fishing. Of the various substances used for impregnating cotton nets, the first class to be considered are tanning materals, which have been employed for the preservation of nets, fishing lines, and sails in all parts of the world from the earliest times down to the present day.

Tanning materials consist of the bark or other parts of various trees which produce a reddish or brown solution when steeped in cold water or boiled in water, and there is scarcely any tree or shrub which does not contain, in some part, either the bark, wood, fruit, galls, or roots, soluble substances having the properties we are about to consider.

*To preserve nets or cordage*

they are dipped in a hot solution of the tanning substance. In former times, and in some countries still, raw materials, such as oak bark, or the bark of other

trees, were boiled to make the solution, but in the present practice the substance used is 'cutch,' which has previously been extracted by boiling from the raw material. The effect of the tanning solution is to give the cotton or hemp a brown colour, turning darker with time, to shrink it considerably, and to preserve it from rotting. The effect is not very permanent. The nets or lines must be dipped in the hot liquid from time to time to keep them in good condition, and when they are put into the sea after they have been dipped, much of the tanning substance is seen to wash out of them.

A tanning solution shows more special properties when it is applied to hides or skins, which, by its action, are converted into leather. The use of tanning materials in the manufacture of leather is as ancient and more important than their use for net-curing. The changes which occur when a raw hide is converted by tanning into leather are principally two—the hide when boiled in water for some time is nearly all dissolved, the leather is not; the hide when kept damp soon putrefies, the leather does not. Tanning then converts a soluble animal substance which easily putrefies into an insoluble substance which does not putrefy. There is one important difference between the action of the tanning solution on hide and on cotton or other vegetable fibre. When the tanned cotton is soaked in water or boiled, nearly all the tanning substance can be dissolved out again; when leather is boiled, scarcely any of the tanning substance is removed. The tanning matter, in fact, forms a chemical combination with the substance of the hide, but does not combine, or combines only to

a very slight degree, with the substance of the cotton.

The chemical combination that takes place in the making of leather is seen very clearly by adding a solution of tanning material to a solution of gelatine. Gelatine is simply the substance dissolved from the skin or bones of animals by boiling. It is soluble in hot water, and forms a jelly when cold. It may be completely dried without altering its properties; when moistened again it absorbs water and swells into a jelly, which becomes liquid when heated or put into hot water. If a solution of tanning material be mixed with a solution of gelatine, a combination of the two substances immediately takes place, forming a pasty solid precipitate which is of the same nature as leather.

The chemistry of tanning substances is somewhat difficult, and has not yet been completely explained. The substance which is obtained by steeping the raw material, such as oak bark, in cold water, or boiling it, is not a single substance which always shows the same properties, but a mixture of substances which it is very difficult to separate from one another, and slight changes convert one of these substances into another. The chemical analysis of tanning materials has hitherto been carried out for the benefit of the leather manufacturing industry, and it is doubtful whether the methods adopted are the most suitable with regard to net-curing, although they are generally used for both industries.

The substance which precipitates gelatine, or converts hide into leather, is called tannin or tannic acid, and as in the leather industry tanning liquors are used in the

cold condition, it must be assumed that tannin is soluble in cold water. But it has been found that substances which are alike in the true tanning property of making leather show certain differences in other chemical actions and in chemical composition. Thus

*there is not one single tannin*

but several which differ slightly from one another, and these are found to form two chief classes or divisions. One kind of tannin occurs in an almost pure state in oak-galls, the round growths formed on oak trees, and often known popularly as oak-apples. These galls are produced on the twigs of the tree in consequence of the presence of a little maggot in the bark. A certain fly, called the gall-fly, makes a cut in the bark and deposits its egg in the cut. The egg hatches into a maggot, and the irritation of its presence causes the growth of the gall within which the maggot lives and grows until it is ready to change into the perfect fly, when it gnaws its way out of the gall and escapes.

HEMP PLANT.

The most valuable galls are those obtained from the Levant, where they are produced by a small oak of a species different from our English oak. To obtain tannin from the galls they are crushed and soaked in tepid water (104 deg. to 140 deg. Fahr.) until a strong solution is obtained, which is then settled and filtered.

The solution is then shaken with common ether and allowed to stand. The ether dissolves the colouring matters, resins, and fat, and the tannin is left in the water. When the mixture is allowed to stand, the water and ether separate into two layers, the ether is drawn off, while the watery solution is boiled to a syrup, and then spread out on tin plates to dry. The tannin thus obtained is a light powdery substance of slight yellowish colour. It may be obtained at any chemist's, and is used for medical purposes, and on a large scale as a mordant in dyeing. This substance is distinguished as gallotannic acid, to distinguish it from other tannins which are not exactly the same.

By similar processes tannins have been separated from other tanning materials, purified as much as possible, and then chemically investigated. In all cases the purified tannin is almost colourless, and is soluble in cold water. The colouring matter in tanning solutions, therefore, is not actually tannin.

Before proceeding further with the chemistry of tanning substances, we may briefly describe

*the principal tanning materials*

which are in use. They are put upon the market either in the natural raw condition or in the form of extracts. The latter consist of the soluble substances 'extracted' from the raw materials by boiling, and then evaporating the water until the extract is nearly dry, or until the solution is reduced to a thick syrup. In the former case the product is a dry extract, in the latter a liquid extract.

Oak bark—the bark of the common English oak—is largely used for tanning leather. The bark of another

species in Turkey and of the chestnut oak (*Quercus castanea*) of America are also used. The bark is stripped from the trees when they are about fifteen years old.

Hemlock bark is really the bark of a kind of pine abundant in America, called the Canadian pine (*Abies canadensis*). It is the principal tanning material of the United States. The extract of this material in liquid form has been recommended for net-curing under the name of Canada cutch, and is sold in tins containing about 3 lb. weight.

Mimosa, or Wattle bark, is obtained from various *Mimoseæ* or acacia trees growing in Australia, where this is the staple tanning material.

Quebracho is obtained from several kinds of South American trees. It is imported largely in the form of both dry and liquid extracts.

Valonia consists, not of the bark, but of the cups of the acorns of a certain oak (*Quercus ægylops*) growing in the Levant.

Sumach consists of the leaves of a plant dried and ground. The plant grows in the South of Europe.

Gambier, or terra japonica, is a dry extract prepared from the leaves and twigs of a tree called *Uncaria gambier* in the Malay Peninsula. It is imported from Singapore. There are two forms—block gambier in large masses, and cube gambier in small light yellow cubes. It is not much used for net-curing, but I believe has been used in former times at some places, such as Clovelly, under the name of catechu.

True cutch, or catechu, is a dry extract made from the wood of a tree called *Acacia catechu*, which grows in India and Burmah. It may be distinguished as

Burmah cutch, as its manufacture is carried on chiefly by natives, according to their own traditional methods, in Burmah. It is imported from Rangoon. Until recently it was used everywhere round the British coasts for net-curing, and was used in far larger quantities for the purpose than any other tanning material.

Red cutch or mangrove cutch is made from the bark of mangrove trees, which grow in swamps at the mouths of rivers in tropical countries. (See Frontispiece.) This cutch is now manufactured extensively by two

MANGROVE TREE.

British companies in Borneo, and is largely used for net-curing, having replaced Burmah cutch to a considerable extent.

Myrobalans, divi-divi, and algarobilla are raw materials consisting of the dried fruits or seed pods of different trees. They are imported for use in the leather industry, but are not used for net-curing. Canaigre is also a raw material, consisting of the root of a plant growing in New Mexico and Arizona, not used for the fishing industry.

### *Analysis of cutch.*

As the composition of the soluble substances yielded by different tanning materials varies considerably, and accordingly the tanning power of a given quantity varies, and as materials may even be adulterated intentionally before being sent to market, it is very important to have a method of testing the amount of actual tanning substance, or tannin, in a sample. The methods mentioned above of separating tannins in a more or less pure state are not suitable for the purpose of such testing, because in the first place they are too tedious and complicated, and in the second they do not separate the whole of the tannin, but only obtain a portion of it in as pure a condition as possible.

### *The gelatine method.*

The first method used for comparing the amount of tannin in different tanning materials was that suggested by Sir Humphry Davy nearly a century ago, which was founded on the fact above mentioned that tannin precipitates a solution of gelatine. In this method 480 grains of the tannin material were either steeped or boiled in a certain quantity of water, half-pint or one pint, and then mixed with a solution of glue (which is an impure form of gelatine) of the strength of 60 grains to a pint. The precipitate was filtered off, then dried and weighed, and four-tenths of this weight were reckoned to be tannin, the rest gelatine. There are various objections to the method: the filtering of the precipitate with some tanning materials is almost impossible, the amount of tannin in the precipitate is not always four-tenths, but

sometimes more and sometimes less, so that different results are obtained at different experiments with the same material. This method is not now generally used by technical chemists.

*The permanganate of potash method.*

Another method is to find out how much permanganate of potash is required to oxidise the tannin. These are terms which will not be easily understood by those who have not studied chemistry, but a little explanation will enable anyone to understand them sufficiently for practical purposes. Oxygen is the active constituent of air, of which it forms one-fifth part. Solutions of tannin absorb oxygen from the air gradually, and the tannin combined with oxygen loses its tanning properties. Permanganate of potash is one of a class of chemical substances which contain much oxygen, and readily part with it to other substances. Thus when permanganate of potash is added to a tanning solution, the tannin is oxidised, and the more tannin there is present, the more permanganate is required to oxidise it. In order to see how much permanganate is used up by the tannin, the tanning solution to be tested is mixed with a certain quantity of a solution of a compound of indigo, which is of a dark blue colour. So long as the tannin is being oxodised the indigo is unaltered, but when all the tannin is oxodised, then the permanganate attacks the indigo and takes all the colour out of it.

The practical working of the method is as follows:— Solutions are made of a certain strength of permanganate of potash, of the indigo, and of the tanning

material to be tested. First of all a certain quantity of the indigo solution is taken and put into a glass flask, with about a quart of water. The permanganate of potash is put into what is called a burette, which is a tube with measures marked on it and a tap at the bottom, so that the amount of the solution used can be measured. This tube is supported on a stand above the flask containing the indigo, and permanganate

Cotton Plant.

is dropped into the indigo solution until all the blue colour is gone. The quantity of permanganate used is then noted. Then the same quantity of indigo is taken again, and a certain quantity of the tanning solution also is mixed with it, and the operation of adding the permanganate is repeated. This time more perman-

ganate is used than with the indigo alone, and the difference is the amount used by the tannin. In the same way, the amount of permanganate used by a solution of pure tannin is ascertained, and by comparison the amount of tannin in any solution tested is found. There are, however, other substances in a tanning solution besides the tannin which are oxidised by permanganate, and where great accuracy is required; the amount of these other substances is found by removing the tannin from a portion of the solution, by adding a solution of gelatine, and then trying how much permanganate is used up by the solution after the tannin has been removed.

The permanganate method of testing only tells us what percentage of oak-gall tannin, or gallotannic acid, would be equivalent to the tanning solution tested. Thus it may be found that a solution requires half as much permanganate as the same quantity of a solution of pure tannic acid of the same strength, and then we say that the tanning material tested contains 50 per cent. tannin. But the particular kind of tannin which the tanning material contains may consume more or less permanganate than the same weight of gallotannic acid, and the percentage of this particular tannin in the material tested may be more or less than 50 per cent.

### *The hide-powder method.*

In the tanning process other substances are absorbed by hides, in addition to pure tannin, and as leather is sold by weight, it is useful to the tanner to know exactly how much weight will be added to the hide when it is tanned by the materials he is using. Leather-

trades' chemists have, therefore, agreed to use a method which shows how much of the tanning material is actually absorbed by hide substance from a tanning material. The method is, in principle, extremely simple, though it takes a considerable time to carry out. The hide substance is used in a form called hide-powder, which is made from ox-hide that has been thoroughly washed, cleaned, and deprived of hair, and then dried and reduced to a fine woolly powder by grinding in a suitable mill.

The analysis is made by weighing, and, therefore, a delicate chemical balance is required for the purpose, as the quantities to be weighed are extremely small. A certain weighed quantity of the sample to be tested is taken—for example, Burmah cutch—and is dissolved in boiling water. When all is dissolved, cold water is added to make up the solution to a certain measure (a litre). The solution is then cooled and filtered, by which process that portion of the material which is soluble in cold water is separated from the rest. This is necessary for the purpose of the leather manufacture, tanning being carried on in cold liquors, so that only the tannin which is soluble in cold water acts upon the hides. A measured portion of the filtered solution is then boiled down till all the water is evaporated, and the solid matter left behind, which is called the residue, is dried and weighed. In this way the first figure in the analysis is obtained, the proportion of dry soluble matter in the weighed quantity taken for analysis. The remainder is the insoluble matter, which to the tanner is of no use, and the water, that is to say, the moisture in the material, for, of course, tanning materials as sold and

used are not perfectly dry. Thus, if 10 grammes of cutch are taken, the soluble portion may be only six or seven grammes, the rest being water and insoluble matter. In this case the total soluble matter would be 60 or 70 per cent.

The next operation is to find, by means of the hide-powder, how much tanning substance the filtered solution contains. A small quantity of hide-powder is packed in a bottle with no bottom to it, and the neck of the bottle is fitted with a bent tube to act as a syphon. A certain quantity of the solution is then syphoned through the hide-powder, which takes up the tanning matters just as a hide or skin takes them up in the tanning process. The solution that has passed through the hide-powder is thus deprived of its tanning matter, or tannins, and contains only substances which are not capable of tanning. This solution is evaporated and the dried residue is again weighed, which gives the amount of non-tanning soluble matters in the sample. The difference between this and the total soluble matter is the amount of tanning matter in the sample.

Thus the method gives, not the proportion of pure tannin, but the proportion of all substances which are absorbed by hide substance, which, for practical purposes, is what the tanner requires to know.

Having thus found the exact percentage of tanning matters and of soluble non-tanning matters, in the perfectly dry state, which the sample contains, the only remaining question is how much of the total weight of the sample is water and how much dry solid matter. This question is answered by weighing a small quantity of the sample and then placing it in a drying oven

at a temperature of about 110 deg. of the centigrade thermometer, or a little above the boiling point of water, and finally weighing it again. The loss of weight after drying is, of course, the weight of water that was in the sample. As water has a very heavy weight, the percentage of moisture in cutch or other tanning materials is of considerable commercial importance, as a ton of cutch after simply being stored a few months may be reduced to 19 cwt. As the moisture evaporates, the percentage of tannins necessarily increases, and, therefore, the loss of weight by drying is no disadvantage to the user of the cutch, but it may mean a loss of money to a merchant if he buys a ton and has only 19 cwt. to sell.

Thus the hide-powder analysis divides the tanning material into four parts, as follows:—

1. *Soluble tanning matter*, which is the portion which combines with hide to form leather.

2. *Soluble non-tanning matter*, which is of no value to the tanner.

3. *Insoluble matter*, that is to say, the fraction which is not soluble in cold water.

4. *Moisture*, or the proportion of water in the sample, which is removed by simple drying.

For example, an analysis by this method of Burmah cutch, obtained in Newlyn in 1899, gave the following result:—

| | |
|---|---|
| Tannins . . . . . | 46·6 per cent. |
| Non-tannins . . . . . | 20·0 „ |
| Insoluble . . . . . | 11·5 „ |
| Water . . . . . | 21·9 „ |
| | 100·0 |

As I have already pointed out, these methods of analysis were invented and are used chiefly for the benefit of the tanning industry, the manufacture of leather. It is generally assumed that the value of cutch for curing nets depends on the proportion of tannin which it contains, and cutch merchants, therefore, rely upon the methods above described and quote the percentage of tannin as the most important proof of the quality of the cutch which they supply to the fishing industry.

## CHAPTER II

### THE NET-CURING PROPERTIES OF CUTCH, AND THE EFFECTS OF SODA, BICHROMATE OF POTASH, ETC.

*Difference between tanning and net-curing.*

It is evident, however, that there is one great difference between the use of cutch for curing nets and of tanning materials for making leather. For curing nets the cutch is boiled and used in hot solution, not cold. In boiling water nearly all the cutch is dissolved, or, as the Cornish fishermen say, 'goes abroad,' and is, therefore, taken up by the dry cotton when the net is dipped. The part which is not dissolved by boiling water consists merely of impurities. For example, in Burmah cutch there is usually a certain amount of leaves, twigs, and sand which are entirely useless, but which do not form a large percentage of the weight. In the red mangrove cutches from Borneo I have found nothing of this kind, nothing which is not dissolved after boiling for some time.

In the ordinary use of Burmah cutch for net-curing the fact that a portion of the substance is soluble in hot water but not in cold makes itself obvious. The hot liquor, free from any of the solid rubbish at the

bottom of the boiler, is perfectly liquid, but if it is allowed to stand in a bucket till it is cold, there is found a quantity of muddy sediment at the bottom. If the liquor with the sediment is heated again, the sediment disappears.

It is an important question whether this portion of the cutch, which is insoluble in cold water, and, therefore, useless in leather manufacture, is equally useless for net-curing. If it has any preserving properties at all, its effects on the net will be more durable than that of the tannin, which is soluble in cold water, for the cold salt water of the sea will not wash it out of the net, as it washes out the soluble tannin. In fact the cord of a net that has been in use some time, and has been cured by repeated dips in cutch, is found to be much thicker than the cord of a new net. The cord becomes loaded or 'filled' with solid substance derived from the cutch, which is not dissolved by the sea water.

Practical experiments, to be described below, have shown that the portion of the cutch we are considering is by no means useless in net-curing, but has great preserving power. In fact it possesses tanning properties, as can easily be shown by separating some of it by filtering, dissolving it in hot water, and mixing it with a solution of glue or gelatine. It consists of a mixture of substances which chemically differ but slightly from the tannin of cutch, and it is probable that tannin can be converted into these substances, or produced from them. One of the substances is called *catechin*, which, in the pure state, consists of white crystals; the others are colouring matters.

*Practical experiments to test the preserving power of different cutches.*

In order to test the actual preserving power of different samples of cutch, I adopted, in my investigations in Cornwall, the following method. I procured a machine for testing the strength of a net before and after the experiments. The principal part of such a machine, which is called a dynamometer, is of the nature of a spring balance. One mesh of the net is attached to the spring, another at a certain distance to a hook or knob, which can be pulled away gradually by turning a handle. As the strain increases the hand on the dial of the balance indicates in pounds and ounces the weight which is equal to the strain until one of the meshes breaks, when the hand shows the number of pounds equal to the breaking strain.

In comparing the value of different materials or processes of curing, I took pieces cut from the same net, and, therefore, when new of the same strength, cured them, and then fastened them to a mooring at the bottom of Newlyn Harbour. After they had been under water for a certain time, the pieces were taken up and tested on the dynamometer, and found to be of very different strengths, which showed the differences in the preserving properties of the various materials or processes.

One of the earliest experiments carried out on this method proves the preserving power of that part of cutch which is insoluble in cold water. So far as I know, there is no natural cutch or tanning extract which is completely soluble in cold water, for the very good reason that the cutch or extract is generally made

by boiling. But some of the red cutches put upon the market by the Borneo companies are almost entirely soluble in the cold, either because they have been chemically treated, or because the insoluble part has been removed from them.

In this experiment I tested four kinds of cutch: 1, Burmah cutch; 2, Mangrove T.; 3, Mangrove M.; 4, Mangrove C. The last three were red or mangrove cutches from Borneo. In every case the strength of solution used was 1 lb. to one gallon of water; the net was dipped twice, being left half-an-hour in the liquor each time, and dried between the two dips. The pieces of cured net were left under water, uncovered only at low water in spring tides, for five weeks, and then tested.

The analyses of the different kinds of cutch by the hide-powder method were as follow:—

| | Burmah Cutch. | Mangrove T. | Mangrove M. | Mangrove C. |
|---|---|---|---|---|
| Tannins . . | 46·6 | 46·0 | 45·2 | 50·8 |
| Non-tannins . | 20·0 | 9·8 | 15·6 | 14·9 |
| Insoluble . . | 11·5 | 17·1 | 4·8 | 2·2 |
| Water . . | 21·9 | 27·1 | 34·4 | 32·1 |
| | 100·0 | 100·0 | 100·0 | 100·0 |

So that the mangrove C. contained the highest percentage of tannin, and at the same time the lowest percentage of insoluble matter.

The strengths after exposure in the harbour were as follow:—

| Burmah Cutch. | Mangrove T. | Mangrove M. | Mangrove C. |
|---|---|---|---|
| 5 lb. 6 oz. | 8 lb. | 2 lb. 2 oz. | 2 lb. 9 oz. |

This shows that the mangrove T. was far superior to

the three other kinds in preserving power, and that the mangrove C., though it had the highest percentage of tannin, was far inferior to either the mangrove T. or the Burmah cutch.

In spite of this, however, the original brand of mangrove T. cutch did not become popular. The large amount of insoluble matter, which increased the net-curing quality, was considered objectionable by practical men, because it settled at the bottom of the boilers when cold cutch was left in them, and caused burning and cracking of the boilers when the fire was lit up next time. The more soluble kinds of red cutch seem now to be the more favoured. I cannot help thinking that this is a mistake.

The question of the best method of analysis for the purpose of net-curing is yet to be settled. The hide-powder method was adopted for the greater part of Europe by the International Association of Leather Trades' Chemists, and perhaps some day a conference may be held in the interests of net-curing to consider the adoption of a standard method for the purposes of the fishing industry. At present, it seems to me that the hide-powder method would serve very well with some modifications. One of these is that the amount of matter insoluble in *boiling* water should be given separately, and also the amount soluble in hot, but insoluble in cold. This last item should, I think, be considered as tannin, and then the apparent superiority of soluble cutches would disappear. For net-curing there can be no doubt that the best cutch is that which has the largest amount of tannin *insoluble* in cold water.

There is another kind of mangrove C. supplied by the same company, which is less soluble than that already

mentioned. I analysed it in the year 1900, with the following result:—

| | |
|---|---|
| Soluble tannins | 46·2 |
| Soluble non-tannins | 15·2 |
| Insoluble in cold water | 14·2 |
| Water | 24·4 |
| | 100·0 |

A hide-powder analysis of a sample of Quebracho gave the following:—

| | |
|---|---|
| Soluble tannins | 52·6 |
| Soluble non-tannins | 15·4 |
| Insoluble | 10·7 |
| Water | 21·3 |
| | 100·0 |

Quebracho has not yet been used for net-curing, and I have not made a thorough trial of it myself, but from the above analysis it is evident that it is little if at all inferior to Burmah cutch.

### *Chemical combinations of cutch.*

In considering the analysis of tanning materials, we have become acquainted with two of the principal chemical combinations formed by tannin—namely, combination with oxygen and combination with gelatine. We have now to consider whether these or any other chemical combinations will enable us to increase the preserving power of cutch on fishing nets. Fishermen have long been in the habit of using various other substances, such as oil and tar products, in addition to cutch, in order to preserve their nets more permanently

and more cheaply, and we shall consider these other substances later. It is well known that when cutch alone is used the nets must be dipped frequently, and this involves a great deal of both labour and expense.

### *Cutch and gelatine.*

The insolubility and durability of the combination of tannins with gelatine suggested to me at one time that this combination would be very successful for net-curing. It was easy enough to soak the net in a hot solution of common glue, or any other form of gelatine, and then to dip it in a hot solution of cutch in the ordinary way. Pieces of net thus prepared were loaded with the leather-like combination of gelatine and tannin. They dried easily like an ordinary cutched net, and seemed in very good condition for fishing. When first prepared the strength of the net was much increased, but when the pieces were tested in the manner already described by exposure in the harbour, the result was a failure. After four weeks in the harbour the pieces prepared with glue and cutch were much weaker than those cured with cutch alone, and I came to the conclusion that although leather is a very durable material on land, the presence of gelatine in the nets, in spite of its combination with tannin, favoured the putrefying and rotting action of bacteria. This method, therefore, is not suitable for curing nets.

### *Cutch and oxygen.*

The action of air or oxygen on tanning materials and the substances derived from them is very interesting,

and gives rise to several industrial processes of great commercial importance. Every fisherman knows that tanned nets, which are of a bright brown or reddish colour when first cured, turn gradually darker with use, until after a time they are nearly or quite black. This change of colour is due to the combination of the cutch with the oxygen of the air and the oxygen dissolved in the sea water. Whether the preservation of the net is improved by the change or not is not quite certain, but it is probable that the cutch in the net is made more insoluble by the combination with oxygen—the *oxidation*, as it is termed.

A solution of cutch, or of tannin, absorbs oxygen from the air if left standing, but very slowly. If, however, caustic potash, or soda, or carbonate of soda, is added to the solution, the absorption of oxygen goes on much more rapidly, and causes the colour to become much darker. There may be a good many amateur photographers in the fish trade, but probably few people are aware of the close connection that exists between the darkening of cutched nets and the development of a photographic negative. This is a good illustration of the interest as well as of the commercial importance of chemical science.

### *Net-curing and photography.*

The substance most largely used as a 'developer' in photography is pyrogallic acid, or, as it is more correctly named, pyrogallol. This substance is prepared by heating from the gallotannic acid made from oak apples, and it is produced by heat from any of the tanning materials that contain that particular kind of

tannin. Pyrogallol as obtained from the dealer is an almost white powdery substance, which dissolves in cold water, forming an almost colourless solution. For use as a developer a certain amount of caustic soda, or carbonate of soda or ammonia, is added to it, and then it is poured over the negative which has been exposed. The result is that the picture, which was before invisible, is developed on the negative, while the pyro-soda developer becomes brown or black. The reason is that the alkaline solution of pyrogallol, by its affinity for oxygen and other elements, decomposes the silver salts in the negative where they have been exposed to the light, and at the same time the pyrogallol forms dark-coloured compounds with the elements which are set free.

It is probable, though I have not made the experiment, that a solution of cutch with caustic soda added would serve as a photographic developer, but not, of course, so perfectly as pure pyrogallol.

It will, of course, be understood that while oxygen in the free state is a gas which forms one-fifth part of the air we breathe, it is contained in the state of combination in many solid substances; for example, in iron rust, which is formed by the combination of the oxygen of the air with the metallic iron. If a substance such as bichromate of potash or permanganate of potash, which contains much oxygen, be put into the pyro-soda solution, the latter almost immediately turns black from the combination of the oxygen with the pyrogallol.

The question arises here whether, since the addition of soda causes cutch to absorb oxygen more quickly, it also increases the net-curing quality of the cutch. It will be found that a net dipped in cutch containing

soda will show a much darker colour, but the soda has another effect on the cutch which is by no means an improvement. A small quantity of soda or other alkali added to a solution of cutch dissolves all the sediment previously mentioned, which in the natural state was insoluble in cold water, and, therefore, the addition of soda causes the cutch to wash out of the net more quickly, and must be considered harmful. In some of my experiments, it is true, soda has seemed to produce slight improvement with Burmah cutch, but usually the effect has been in the opposite direction. In considering the soluble red cutches which are in the market, we shall have to refer again to the effect of a small addition of soda or other alkali in rendering any cutch perfectly soluble in cold water.

*Cutch and bichromate of potash.*

It has been stated that a solution of cutch to which soda has been added absorbs oxygen from the air, and if left to stand for some time, or shaken up with air, it turns a very dark colour. By adding now to the mixture a little acid—hydrochloric, for instance—the soda is neutralised, and a large quanity of solid matter is separated, consisting of the combination of the cutch with oxygen. The same solid compound can be produced in great quantity by adding an oxidising reagent, especially bichromate of potash, and then boiling.

This action of bichromate of potash in producing a dark-coloured insoluble compound from cutch is extensively used in the dyeing industry for the production

of various shades of brown or black in cotton and other fabrics. In fact, for these colours Burmah cutch and gambier, in combination with bichromate of potash, are the best dyes known, and it is stated that artificial sealskin is made by dyeing silk plush by this process.

Bichromate of potash is also regularly used in the furniture trade for giving a darker colour to wood. In this case its action is chemically the same as its action on cutch. The wood contains tannin and similar substances, and these are oxidised by the bichromate, and, therefore, their colour is darkened.

Catechin, which has been mentioned as forming part of the cutch, and which is insoluble in cold water, but soluble in hot, can be separated in the pure state, and is then colourless. But when catechin is mixed with hot bichromate of potash it forms a dark-coloured insoluble compound. In dyeing, however, the cutch is used in the natural state. The cloth is thoroughly soaked in the hot cutch solution, and is then dipped into a hot solution of bichromate of potash of the strength of ¼ lb. to the gallon. If the cutch were used alone the colour would not be permanent when the cloth was washed; in hot water it would continually wash out and run; after the action of the bichromate of potash the colour is fixed, or 'fast,' and does not wash out. There can be little doubt that the bichromate of potash acts not only upon the catechin, but upon the tannin of the cutch, and, in fact, oxidises nearly the whole of the cutch to an insoluble combination.

The effect of the bichromate is strikingly seen if a strong hot solution of it is added to a strong hot solution of cutch in a small vessel. The effect is to turn the liquid cutch into an almost solid jelly, so

that the vessel can be held upside down without spilling the contents.

The effect on a piece of fishing net can easily be tried by dipping the net first in a solution of cutch, which need not be very strong, and then dipping the net into a hot solution of bichromate of potash of 1 to 4 ounces to the gallon. The net, which was light brown or light red from the cutch, is immediately turned almost black, and the colour will not wash out again.

The use of bichromate, then, seems to offer a method by which the cutch which is put into a net may be kept there permanently, and the loss and waste due to the washing out of the cutch in the sea may be prevented. But the question for the fisherman is, whether the net is better cured by the process. We have seen that the dyer obtains a fast colour in this way, and as the process is constantly used in dyeing on a very large scale, we may conclude that the bichromate does not rot the cloth.

For the fisherman's purpose, however, this is not enough. The net must be not merely as well preserved as with cutch alone, but better preserved.

### *Experiments with bichromate of potash*

Accordingly I made at Newlyn a large number of experiments, in the manner already explained, to test whether by the use of bichromate the net could be preserved more successfully or more cheaply, and the results were very favourable. One of the most striking of these experiments was made entirely with Burmah cutch, of the Double Eagle brand. The pieces of net used were cut from a net made at Bridport, 25 rows to

the yard, 12-ply cotton. The strength of this net when tested new and uncured, or white, was 15½ lb. It may be mentioned here that the strength of the net was always measured by pulling upon meshes at the same distance from each other, as otherwise the results would not be obtained under the same conditions. Four pieces of net, cured with and without bichromate, as shown below, were put down in Newlyn Harbour on 31st January 1900, and taken up and tested on 3rd March, so that they were in the water between four and five weeks. The strengths given are the averages of five trials on the testing machine:—

*Experiment I.*

1. Dipped once in Burmah cutch, 1 lb. to 1 gallon water . . . . 4 lb. 2 oz.
2. Dipped *twice* in Burmah cutch of same strength, dried after the first dip . . . . . 6 lb. 5 oz.
3. Dipped once in Burmah cutch, same strength, with 1 oz. bichromate of potash added to 1 gallon of cutch liquor . . . . . 5 lb. 3 oz.
4. Dipped once in Burmah cutch, same strength, then dipped separately in hot solution of bichromate, ½ lb. to 1 gallon water . . . **14** lb. **5** oz.

It will be seen that of these four pieces of net, which were placed in the harbour at the same time fastened to the same piece of rope, three were practically rotten, while the fourth was nearly as strong as when new,

and this fourth piece was the one that had been cured with bichromate of potash.

It will be seen, further, that the second piece in the list had been dipped twice in strong cutch, and, therefore, had received twice as much cutch as the first piece or the fourth, yet it was not much stronger after the test than the first piece. One dip in cutch and one in bichromate is, therefore, very much more effective than two dips in cutch.

The third piece was intended to try whether the bichromate would be successful when mixed with the cutch instead of being used after it. The result is to show that no improvement is effected by the mixture.

The reason of this is not difficult to understand. We have seen that the bichromate precipitates the cutch and renders it insoluble. If this is done before the net is dipped, little or none of the cutch can make its way into the cotton, whereas when it is done after the net is dipped, the cutch is in the cotton and cannot make its way out again. The bichromate must be used separately after the cutch, just as it is used for the purpose of dyeing.

It will be observed that in the above experiment the bichromate was used in a very strong solution. Bichromate of potash is a substance in the form of orange crystals soluble in cold or hot water, and can be purchased for about 6d. per lb. when bought wholesale. If used on white cotton in the strength above given—that is, without cutch—it would easily wash out when the net was placed in water, and if the net was left dry the bichromate would rot the cotton in a very short time. *It must be clearly understood that the bichromate is not*

*itself a preservative; what we are considering is its effect on the cutch, not on the cotton directly.*

Another similar experiment was made with various kinds of cutch with bichromate in weaker solution and with other combinations. In this case there were eleven pieces of net prepared in different ways; they were put down in the harbour 31st January 1900, taken up on 3rd March, put down again on 14th May, finally taken up and tested on 28th May. Thus they were in the harbour six weeks altogether. The results were as follow:—

*Experiment II.*

| | |
|---|---|
| 1. Burmah cutch, 1 lb. to gallon, net put in hot liquor and left to soak twenty-four hours . . . | 4 lb. 14 oz. |
| 2. Mangrove cutch C., a somewhat insoluble kind, same treatment . | 5 lb. 12 oz. |
| 3. Mangrove cutch T., same treatment. | 7 lb. 6 oz. |
| 4. Burmah cutch, same treatment, net then dipped in hot bichromate, 1 oz. to 1 gallon water . . . | 13 lb. 5 oz. |
| 5. Mangrove cutch C., same treatment followed by hot bichromate, same strength . . . . . | 14 lb. 9 oz. |
| 6. Mangrove cutch T., same treatment followed by hot bichromate, same strength . . . . . | 13 lb. 5 oz. |
| 7. Mangrove cutch T., 1 lb., with 1 oz. bichromate, boiled together in 1 gallon water, net left to soak twenty-four hours . . . | 1 lb. 13 oz. |

| | |
|---|---|
| 8. Burmah cutch, 1 lb., with 1 oz. washing soda, boiled together in 1 gallon water, net left to soak twenty-four hours . . . | 6 lb. 12 oz. |
| 9. Mangrove cutch C. and soda, same treatment . . . . . | 4 lb. 2 oz. |
| 10. Burmah cutch, 1 lb. to 1 gallon sea water instead of fresh . . . | 5 lb. 13 oz. |
| 11. Mangrove cutch C. in sea water, same strength . . . . | 6 lb. 5 oz. |

In this experiment it will be seen that the bichromate was used in much weaker solution than in the previous one, yet the enormous superiority of all the pieces treated with it is equally evident. Here, for some reason, the mangrove cutch C., though by itself a little inferior to the T., is rather superior when combined with bichromate. The reason for this is probably that the C. brand, for some reason, gives more solid precipitate with the bichromate.

The failure of the mangrove T. and bichromate mixed together is obvious. The addition of soda causes a slight improvement with the Burmah cutch, but does harm with the mangrove cutch. The use of sea water for dissolving the cutch produces a slightly better effect; the reason of this is probably that salt makes the cutch somewhat less soluble. It will be seen, however, that none of the improvements are important in comparison with that produced by the use of bichromate.

In another experiment Quebracho and cube gambier were tried in comparison with mangrove T. The pieces in this case were left in the harbour from 28th May to 15th July, a period of seven weeks. The pieces of net were cut from another new net, which seems to have

been of better quality than that previously used, as the pieces cured with cutch alone were not so weak after exposure as in previous experiments.

*Experiment III.*

| | | |
|---|---|---|
| 1. Mangrove T. alone, 1 lb. to 1 gallon of water, dipped once, soaked ten minutes . . . . . | 12 lb. | 5 oz. |
| 2. Quebracho alone, same strength, same treatment . . . . | 9 lb. | 5 oz. |
| 3. Cube gambier alone, same strength, same treatment . . . . | 5 lb. | 0 oz. |
| 4. Mangrove T. as before, then dipped in hot bichromate, 1 oz. to 1 gallon water . . . . . | 13 lb. | 8 oz. |
| 5. Quebracho as before, followed by bichromate, 1 oz. to 1 gallon . | 12 lb. | 14 oz. |
| 6. Gambier as before, followed by bichromate, 1 oz. to 1 gallon . | 11 lb. | 5 oz. |
| 7. Mangrove T., 1 lb., soda 1 oz. to 1 gallon water, net dipped in mixture, then dipped in bichromate, 1 oz. to one gallon water . | 7 lb. | 8 oz. |
| 8. Gambier with soda, then bichromate in above proportions . . . | 7 lb. | 12 oz. |
| 9. Mangrove T., ½ lb to ½ gallon water, mixed with ½ pint bichromate solution, 1 oz. to 1 gallon . . | 7 lb. | 8 oz. |
| 10. Quebracho mixed with bichromate, same proportions . . . | 10 lb. | 10 oz. |
| 11. Quebracho, ½ lb., bichromate ½ oz. to 1 gallon water together . . | 5 lb. | 10 oz. |

This experiment shows that the effect of bichromate is just as marked with Quebracho and gambier as it is with Burmah cutch or mangrove cutch. Nos. 7 and 8 show that the effect of the bichromate is much diminished if soda has been added to the cutch previously. Nos. 9 and 10 show that a very small quantity of bichromate added to the cutch produced an improvement in the case of Quebracho, but did harm in the case of mangrove, while No. 11 shows that a little more bichromate mixed with the cutch was harmful with Quebracho. It is clear, therefore, that there is no method of using bichromate and cutch mixed together with advantage; the two must be applied separately.

There are other substances besides bichromate of potash which precipitate cutch or the tannin in cutch. The alkalis, soda, and potash, as we have seen, have a strong solvent effect, and ammonia, which is also an alkali, acts in the same way, but lime causes precipitation. Nearly all metallic salts also form solid compounds with cutch, but so far as I have made experiments, none of these increased the preserving power of the cutch; on the contrary, they rot the cotton; this is the case, for instance, with sulphate of copper, commonly called blue vitriol or bluestone.

### *Use of bichromate in entire nets for practical fishing.*

The experiments described prove beyond a doubt that the use of bichromate increases very greatly the preserving power of cutch, and it may be concluded that a net could be kept strong with fewer dips in cutch if bichromate were used in the manner specified. The

strength of bichromate employed by dyers is 4 oz. to the gallon, and this is the strength I have used for net-curing. I have cured a number of nets in Cornwall by the method, some for myself, some for fishermen, and when the method has been properly carried out the results have been very successful. I have always dipped the net twice in cutch before dipping it in the bichromate, using from ½ lb. to ¾ lb. cutch to the gallon of water. It does not seem to matter very much whether the net is dried before it is dipped in the bichromate or not.

It is probably safer that the net should be used for fishing or washed in the sea immediately after it has been dipped in bichromate, but I have not generally done this, and have found no ill effects from ommitting it.

There is not at present long enough experience to enable me to say that nets cured with bichromate will last longer than those cured with cutch alone, the fact on which I insist is that the net will be equally well cured at half the expense. At present I feel sure that nets are often ruined by being cutched too often, even when cured in the ordinary way, and if they are cutched too frequently after the use of bichromate, the cotton becomes too hard and the mesh too much shrunken. Then there is danger of the knots breaking, and the method may be condemned. The object of the bichromate is to economise cutch.

When cutch alone is used, a net is generally dipped two or three times before being used, or it may be left steeping in cutch a long time. When it is first used it is found necessary to dip it again after about a fortnight, and to dip it frequently during the first season.

After the first season it requires less cutch. On the other hand, I have several times known nets cured in one day with two dips in cutch and one in bichromate, then taken to sea and not dipped again for four, five, or even six weeks, when they were still strong and rough. This is sufficient proof that the method saves a great deal of money and labour. On the other hand, it has been said that the bichromate makes the net too hard and brittle after a time. This may be the case if too much cutch is used, if the nets are dipped too frequently, but I believe not otherwise. To use the method successfully, of course, a little intelligence is required.

I have been informed by M. Roché, Chief Inspector of Sea Fisheries in France, that bichromate of potash is used by the Boulogne fishermen in the way I have here described for fixing the cutch in the nets.

### *Soluble mangrove cutches.*

We have seen that the mangrove cutch from Borneo, which I have called mangrove C., is sold in two forms, one perfectly soluble in cold water, the other not. I have also stated that so far as I know no absolutely natural cutch is perfectly soluble in cold water, but always contains a certain proportion of matter insoluble at ordinary temperatures. The proprietors of mangrove T. have also recently manufactured soluble forms of their product.

I have not analysed these, but I made some tests with them on pieces of net, and found that the soluble brands were inferior in preserving power to the insoluble, when the cutches were used alone. I know

nothing at all of the methods of manufacture of these cutches, but a very small quantity of soda or other alkali added in the process of manufacture would produce complete solubility. And in all probability this is the method employed. Doubtless the amount of soda or alkali present could be ascertained by chemical analysis, not by any of the methods considered in these articles, which show only the proportion of tannins, but by other methods. I have not, however, had time to investigate this question. At present I merely wish to point out that different forms of cutch are sold under the same name, and that the mere statement that a cutch contains a certain large percentage of tannin is not the only thing to be considered with reference to the use of the cutch for curing nets.

## CHAPTER III

### TAR AND TAR PRODUCTS

HAVING thus considered the chemistry of tanning materials, we may proceed to study another class of substances which have strongly antiseptic properties, and are largely used for the preservation of nets, cordage, etc.—namely, different kinds of tar and products derived from them.

These substances, like tanning materials, are all derived from trees or other vegetable formations, but while the tanning materials are obtained by means of solution in water, the tars are obtained by means of heat in the process of distillation. Coal is well known to be a vegetable product, formed from trees and other plants which lived in a remote geological epoch, though I have sometimes found it difficult to convince an audience of fishermen that coal is not a mineral. Coal-tar is obtained by the distillation of coal, wood-tar by the distillation of wood.

Coal is largely distilled in this country in works whose chief purpose is the production of coal-gas for lighting. The coal is heated in large closed ovens, or 'retorts,' of fireclay, and the vapours which are

formed from the coal by the heat are condensed by passing through water and through cold pipes. The water used for condensing dissolves salts of ammonia, while the tar condenses as a black liquid heavier than water, and the gas remains uncondensed and passes on to the gas-holder. The coal is thus separated by the process into four portions,—gas, ammonia compounds soluble in water, coal-tar, and coke, which last remains in the retorts.

Coal-tar is not a simple substance, but a very complex mixture. It is used largely in various ways for preserving nets, but seldom alone. One method is to saturate the dry net, either while it is white or after it has been cutched, with coal-tar, then to wring it through rollers or otherwise, and then spread it out to dry, afterwards dipping it in cutch from time to time in the usual way. Used in this way, or painted on to wood by a brush, tar dries slowly and not very perfectly, as it will nearly always soften and run when warmed.

The drying of tar is due to the evaporation of the volatile substances which it contains, those which are more solid being left behind. Some of these volatile substances will be considered later.

This method of treating a net is very cheap, and tested by the method above described, on pieces of net exposed in a harbour, the preservation is very perfect. A piece of net lost scarcely any strength after two months in the water, and, moreover, a tarred net is distinctly stronger than a cutched net, because the dry tar increases the strength of the cotton fibres, by glueing them together. As an antidote to putrefaction, coal-tar is perfect, no putrefying organisms

being able to live in it. The fibres of the cotton being covered by the tar, do not come actually into contact with water.

For these reasons tar is an excellent preservative for coarse nets for rough use, such as trawl nets. But for drift nets there are many objections to its use in the manner considered. The net is too rigid and stiff, and, therefore, does not usually mesh the fish well, although to some extent the net is made more flexible by occasional dips in hot cutch, which softens the tar and removes a portion of it. The rigidity of the net causes it to wear out mechanically; after two or three years it is apt to give way at the knots, owing to the breaking of the stiffened fibres under the constant bending.

Another method of using coal-tar is to mix some of it with hot cutch and then to dip the net into the mixture. The net is then usually dried without being passed between rollers. According to my experiments, this method is not much better than cutch alone. A single dip in the mixture was as effective as two dips in cutch. The objection to the method is that it is impossible to get the tar uniformly distributed through the net. The tar and cutch solution do not mix thoroughly as spirit and water would mix, but after much stirring the tar is divided into small drops which are scattered about in the cutch. The net when dipped also, being wet with the cutch, does not absorb the tar thoroughly; the effect is, therefore, that the net is sprinkled with little drops of tar. A net thus treated is rather stiffer and less flexible than a cutched net, though not so stiff as a net that has been dipped in tar when dry.

*Distillation of tar.*

The pickle, creosote, or green oil much used in Cornwall, and, I believe, to some extent in Scotland, for preserving drift nets is one of the products obtained by the tar distiller, and to understand its nature it is necessary to have some knowledge of the chemistry of this distillation.

Caol-tar is distilled by being placed in a large cylindrical upright retort holding about 25 tons of the tar. The top of the retort is connected with a pipe leading to cast-iron spiral pipes or worms, cooled by cold water, and the end of the worm leads into a closed tank, in which the condensed liquids are received. Fire is applied to the retort, and as the temperature of the tar gradually rises, vapours of different substances are given off. These different products are separated by changing the receiving tanks from time to time, as the temperature in the retort reaches higher points. The following fractions may be separated, though two of them may be collected together—first runnings, light oil, carbolic oil, creosote oil, anthracene oil. In the retort there remains at the end the pitch, hard or soft according to the point to which the distillation is continued.

The first runnings consist of ammonia liquor and crude naphtha. The light oil is re-distilled and separated into crude naphtha and carbolic oil, which is added to the other carbolic oil. The crude naphtha is washed with caustic soda and strong sulphuric acid, and then distilled again to separate it into benzole and solvent naphtha, which last is used for dissolving indiarubber in the manufacture of waterproof goods.

Carbolic acid is obtained from the carbolic oil by the addition of caustic soda, which combines with the carbolic acid, and the latter is then set free by the addition of sulphuric acid.

The creosote oils, when cold, deposit much of a solid white substance called naphthalene, a single chemical compound of carbon and hydrogen. After purification, naphthalene is used for many purposes, and is sold in chemists' shops under the name albo-carbon, for use as a disinfectant and as a protection from insects. It is much used by naturalists for preserving collections of specimens, and it is also used for enriching gas in the albo-carbon light. The creosote oil is used chiefly for saturating railway sleepers, telegraph poles, harbour piles, and other timber to preserve it from rotting.

Anthracene oil, when cold, similarly consists of a solid substance, consisting of anthracene and other compounds, and a liquid oil. The anthracene is separated by filtration in a press or a centrifugal machine, and when purified is used for making colouring matters for dyeing, being first converted into alizarin, which was formerly obtained from the madder plant. The green oil, or red oil, as it is sometimes called, which is filtered from the anthracene, is usually mixed with the creosote oil, which is sold for preserving timber.

For curing nets the green or anthracene oil, being rather thicker than ordinary creosote, is most suitable, and it can be obtained from the tar-distiller unmixed, if particularly specified. Usually, however, the mixed creosote seems to be used. I have experimented on pieces of net with the green oil, and found its preserving properties very great.

There are many different ways of applying the green

oil or creosote to nets. The net may be well cutched first, then dried, soaked in the green oil when dry, then passed through a wringing machine and spread out to dry; or the net may be passed straight from hot cutch, without drying, through the green oil, and then dried, or instead of the oil alone a mixture of tar and green oil may be used. In whatever way it was applied I found pieces of net treated with green oil had lost but very little strength after two months' exposure in Newlyn Harbour.

There are, however, several drawbacks to the use of green oil or of creosote. One is that the oil dries very slowly and never completely, so that the net is for a long time soft and greasy. Green oil consists of liquid oils containing some anthracene in solution, while ordinary creosote contains some naphthalene, and usually some carbolic acid and other compounds. All these compounds, both solid and liquid, are volatile, and, therefore, evaporate from the net gradually, but very slowly. The nets are always dipped in cutch afterwards from time to time, and the effect of this is to remove much of the green oil or creosote, leaving, however, a trace behind, which tends to preserve the cotton, while at the same time the net is made drier and rougher. It is often said that a creosoted net does not get into good condition before its second season.

I have often heard it stated that handling and carrying creosoted nets causes a painful irritation of the skin, and the women who are employed to mend such nets often make great complaints on this account. I have never experienced any such effects myself, though I have handled creosote and green oil a good deal, but there is a chemical compound contained in creosote oil

which is known to have an irritating effect on the human skin. This substance is called acridine.

Another objection which has been sometimes made to the use of 'pickle' for preserving nets is that it affects the fish which are caught in them, the fish when eaten causing a burning sensation in the throat and stomach. This objection refers to pilchards; I have never heard it applied in connection with other fish. I have never been able to verify the truth of this complaint, but it seems possible that pilchards may occasionally absorb a trace of the creosote when the nets have been saturated with it and not properly wrung or cutched afterwards, and when the fish have been left in the nets in the boat for some hours before being unmeshed.

Some fishermen say that creosoted nets are more liable to heat than others, and in order to discuss this point it is necessary to consider the heating of nets in general.

*Heating of nets.*

It is well known to drift fishermen that the spontaneous generation of heat by nets piled together is a frequent cause of damage, a risk against which the owner must be always on his guard. Usually the cause of the heat is not so much in the nets themselves as in the oil, blood, and other organic matter which are derived from the fish meshed in the nets, and the risk is particularly great after a heavy catch of pilchards or herrings. The heat is produced by the process of oxidation, the oxygen of the air combining with the organic matter with which the nets are saturated. In the case of blood or flesh, the oxidation depends on

the bacteria which cause putrefaction, but oil may oxidise directly without the action of bacteria. The process of oxidation necessarily produces heat, and in a large mass of nets the heat cannot escape except on the outside of the mass, so that the temperature inside the mass rises more and more, and the higher it rises the more rapidly the oxidation goes on, until it sometimes happens that the mass of nets actually takes fire.

Without actual firing, however, the heating of the nets may seriously diminish their strength, as the oxidation soon affects the substance of the cotton. This is one of the reasons for 'barking' the nets, as a dip in hot cutch removes the slime and oil derived from the fish. Salt is used to prevent heating, which it does by preventing decomposition, and by reducing the temperature in the process of melting.

I have not yet been able to understand how creosoted nets can be more liable to heat than others. The creosote is strongly antiseptic, and, therefore, tends to prevent decomposition, and I have not ascertained that the creosote itself is liable to oxidation, except when it is actually burnt. There is, however, a possibility that when mixed with organic matter in the nets the compounds contained in creosote have a tendency to chemical oxidation independent of the action of bacteria. This is one of the points in the chemistry of net-curing which requires further investigation.

### *Wood tar—Stockholm tar—Archangel tar.*

Wood is largely distilled in closed retorts in the same manner as coal, the products being gas, wood-spirit, acetic acid, wood tar, and charcoal, the last of

which is left in the retort. A much older method of obtaining charcoal and tar is that of burning the wood in stacks partly covered, so that only a limited supply of air is admitted. In this case the burning of a portion of the wood produces enough heat to decompose the remainder, and the greater part of the wood is reduced to charcoal, while the gas escapes and the tar runs to the bottom of the stack. Even in burning wood in an ordinary fire with an unlimited supply of air the natural decomposition by heat can be observed, for after the flame has ceased some charcoal is left, the flame is produced by the burning gases, and frequently liquid tar can be seen on the surface of the burning sticks.

When charcoal is the principal product required, no arrangements are made to save the tar, but the wood of the pine forests of Sweden is largely burnt for the special purpose of making the tar so well known among all seafaring men as Stockholm tar. For this purpose the wood is packed in a large hole in the ground with a trench at the bottom. The top is partly covered over with earth and turf, and the pile of wood is set on fire at the top. The tar then collects in the trench at the bottom, from which it is obtained after the burning is finished. Russian or Archangel tar is similarly manufactured. By distilling the wood-tar in closed retorts wood-tar creosote is obtained, and pitch is left in the retort. This wood-pitch is known in the trade as Swedish pitch, and is quite distinct from the pitch made from coal tar.

Stockholm tar is used for net-curing in methods similar to those used for coal tar. A favourite method is to mix it with the hot cutch, both in curing a new

net and in barking nets that are in use. The effect, according to my experiments, was very similar to that of the mixture of cutch and coal tar; a single dip preserved a piece of net in Newlyn Harbour for one month, but not for two months. This is the method generally followed by the Mevagissey men. Sometimes a net, wet from the hot cutch, is passed through a mixture of Stockholm tar and coal tar. Stockholm tar does not mix completely with the watery solution of hot cutch, but it contains more matter soluble in water than coal tar. It does not appear to make the nets so hard as coal tar, and, therefore, is not so likely to cause breaking at the knots.

## CHAPTER IV

### NET-CURING WITH LINSEED OIL AND OTHER PROCESSES

*Linseed oil.*

THE chief characteristics of oils and fats, which are derived from animals and vegetables, are that they are insoluble in water, soluble in ether and benzene and a few other liquids, that when heated they do not evaporate, but decompose, and that they combine with caustic alkalis to make soap. Chemically they contain only the three elements—carbon, oxygen, and hydrogen, in this respect resembling starch and sugar; but whereas in the latter the oxygen and hydrogen are in the same proportion as in water, in fats and oils there is much less oxygen in proportion. Fats, therefore, produce much more heat in burning than starch and sugar.

The chemical composition of oils is clearly shown in the manufacture of soaps, a subject which is directly connected with the soap and copper sulphate process, to be considered later. The first part of the process of soap-making consists in heating the fat, tallow for instance, in a copper till it is liquid, and then running in a solution of caustic soda of about 10 per cent. strength: the alkali is known as lye. The mixture

gradually becomes completely liquid, the caustic soda combining with the fat and forming substances soluble in water. Salt is then added, and the soap is thus rendered insoluble, and rises to the top, while the brine below contains glycerine, which is dissolved in it. Thus the fat which is insoluble in water is separated into two substances—namely, soap and glycerine, each of which is soluble in water.

Further chemical investigation shows that a fat or oil consists of a compound called glyceryl, combined with what are called fatty acids, and soap is the combination of a fatty acid with soda or potash. Potash soaps are usually soft soaps. The difference between different fats and oils is due to the different fatty acids they contain, while glycerine is the combination of the compound glyceryl with water.

In their natural state all oils and fats gradually suffer change when exposed to air and light, but there is a great difference in the results of the change in different oils. The change is due to oxidation, and the difference depends on the particular fatty acids present. Whereas in some cases the oxidation causes decomposition, and the oil or fat becomes rancid with a nauseous smell and taste, in others no decomposition occurs, but a solid resinous compound is formed, and the oil is said to dry. The drying of an oil in this way is thus very different from the drying of a watery solution, such as cutch liquor. In the latter case the water is removed by evaporation and the solid matter is left behind; in the case of a drying oil there is no evaporation, but by combination with the oxygen of the air a dry solid compound is formed. Thus when a watery solution, such as cutch, dries, it loses a great deal of weight in con-

sequence of the loss of water, whereas linseed oil in drying becomes heavier, because it takes up oxygen.

Linseed oil is the most important of the drying oils, and is largely used for a great many purposes, most largely, perhaps, as the liquid part of nearly all paints.

Flax Plant.

Linseed oil is obtained from the seed of the flax plant by means of crushing and pressure. The seed contains from 30 to 35 per cent. by weight of oil, and in manufacture about 26 per cent. is extracted. The seed is first crushed in a mill, and then warmed and pressed

in a hydraulic press. The crushed seed after the oil has been pressed out is made into oil-cake for feeding cattle.

Boiled oil is raw linseed oil which has been heated, with the addition of certain substances called driers, to a temperature considerably above that of boiling water, for several hours. Driers consist of lead oxide or litharge and other chemical compounds, which are added and mixed with the oil to the amount of about 5 per cent.

Boiled oil is darker than raw oil, and heavier; it dries more quickly, having already been oxidised to some extent in the process of boiling. Linoleum is made by exposing partly boiled oil to the air on rough cloth called scrim, and then working in cork powder and resin into the gelatinous material.

For curing nets raw linseed oil may be used, or a mixture of raw and boiled. The net is usually first cutched and dried, then saturated with the oil, squeezed out, and then spread out to dry. In this process of drying much heat is produced, and, if the nets are massed in a heap before the drying is completed, they either take fire or lose nearly all their strength through heating. The drying ought to be carried out in the open air on the ground in winter time and in dry weather. This method is generally employed by the fishermen of Lowestoft and Yarmouth, where the extensive flats along the shore, called the denes, offer every facility for the proper drying of the nets. It requires two or three weeks, or even longer, to dry the nets thoroughly, and after this they are again dipped in hot cutch, which removes any of the oil that may be left undried, and covers the dried oil with a coating of

cutch, which protects it from the air. Oiled nets are dipped in cutch from time to time like ordinary nets, in order to clean them and keep them in good condition, but they do not require to be dipped so often as nets cured with cutch alone.

Oiled nets properly taken care of are very strong and durable, as the cotton is protected from the water, and the dried oil gives additional strength by glueing the fibres together and protecting them from mechanical wear. The process, however, is expensive on account of the high price of the oil, and for a time the nets are more liable to heat than nets cured in other ways. For nets constantly in the water, such as trammels and moored nets, curing with oil is very suitable. In the experiments which I made at Newlyn, in 1899, pieces of net cured with cutch and linseed oil showed no loss of strength after two months' exposure in the harbour. In Cornwall, however, the method is not in use, partly on account of the expense, partly for lack of suitable grounds for drying the nets.

In some places linseed oil is used for curing nets white without cutch, and in this condition the nets are said to catch more herrings than the brown cutched nets. This method is used at Clovelly, on the north coast of Devon. In ordinary drift net fishing after sunset, according to my experience, no colour seems to make the net less visible than the dark brown of cutched nets, but if any other colour is required in daylight fishing, it can easily be produced by curing the nets with coloured linseed oil, which is much the same thing as ordinary paint, but, of course, in such a case the nets must not be cutched afterwards, or before.

*Curing with copper sulphate.*

Another method of curing nets with which I have made experiments is that of dipping them first in soap and then in a solution of copper sulphate. In a paper published in the journal of the German Fisheries Society, it was stated that this method was used for giving the nets a green colour in the French sardine fishery, but precise particulars of the process were not given.

As fatty acids combine with soda or potash to form ordinary soap, so they will combine with a metal to form an insoluble soap. When a salt of a metal such as copper sulphate is dissolved, and the solution is added to a warm solution of ordinary soap, a thick insoluble precipitate or curd is formed which consists of a metal soap, the combination of the metal with the fatty acid of the soap. If copper sulphate is used, the copper soap formed is of a bright green colour. If a piece of net is dipped in a hot solution of soap, and then after being wrung out is put into a strong solution of copper sulphate, the insoluble copper soap is formed in the fibre of the cotton, and the net acquires a beautiful green colour, which does not wash out for a long time.

To treat a net by this process, from $\frac{1}{2}$ lb. to $\frac{3}{4}$ lb. of ordinary soap, such as mottled soap or Sunlight soap, is used for each gallon of water, and the soap is dissolved by boiling in a copper, or in a galvanised bath over a fire. The net is then soaked in the soap solution, taken out, squeezed through the hands, and allowed to drain. The copper sulphate, which is also known as blue vitriol, or bluestone, must not be dissolved in an iron vessel, as it will attack and dissolve the iron. It must

be put into a wooden or earthenware vessel, and it is not necessary to use heat to dissolve it, as it will dissolve in cold water if stirred up for a short time. The net, while still hot from the soap solution, is then passed through, or put into, the solution of bluestone, and the whole net becomes uniformly green. The net is then rinsed in cold water. About $\frac{3}{4}$ lb. of the bluestone to a gallon of water is the proportion required.

The net by this method is cured or preserved, not merely coloured, but the preservation is purely antiseptic. In other words, the copper soap is fatal to bacteria, and, therefore, preserves the net from rotting, but it adds no strength or protection to the cotton fibre by mechanical means, like tar, cutch, and linseed oil, because the copper soap is of a powdery nature and has no tenacity.

A piece of net cured by this method and exposed in Newlyn Harbour had lost no strength after four weeks, but after two months it was quite rotten. The process, however, like that of dipping in cutch, can be repeated as often as desired, and, therefore, a net could be kept in condition for years by dipping it in the soap and copper solution from time to time. As copper sulphate is poisonous, it might be thought that it was dangerous to use nets cured in this way for catching fish, but the copper soap is insoluble, and, therefore, does not affect the fish.

I have had trials made with various nets cured in this way—pilchard nets, mackerel nets and small-meshed pilchard nets. It was found difficult to give a proper trial to a single net cured with copper sulphate which had to be worked with a fleet of cutched nets. When the other nets were barked, the green net

necessarily got stained by the cutch, and in such cases it was sometimes decided to cutch the green net entirely. A net thus treated invariably became rotten after a short time, so that there is evidently something in the combination of cutch and copper sulphate which injures the cotton.

I have tried the effect of cutch and copper sulphate together, without soap, on pieces of net, and found it injurious. A piece of net soaked for two days in cutch, 1 lb. to the gallon, and then put into a solution of copper sulphate, lost half of its strength after being in the water for four weeks, and after two months was quite rotten. Tannin is precipitated by most metals, and metallic salts are used in dyeing cotton in combination with tannin as a mordant. I thought, therefore, that a metallic salt like copper sulphate would, by making the tannin insoluble, prevent the cutch from washing out and make its preserving effect more durable. The result, however, was to prove the injurious effect of the copper compound, which appears to be due to the metal itself, not to the sulphuric acid combined with it. In cotton-dyeing the tannin is fixed with tartrate of antimony or chloride of tin, and whether these compounds would be any more advantageous for net-curing than copper sulphate I do not know, as I have made no experiments with them.

It was stated in the German paper to which I have referred that the soap and copper sulphate process is used for curing sardine nets on the West Coast of France for the sake of the green colour which makes the nets less visible to the fish in the water. M. G. Roché, in a little book, entitled *Pêches Maritimes Modernes de la France*, published about 1895, makes

a similar statement, expressly mentioning that sulphate of copper is used to give a colour which makes the net less visible, but he gives no details of the process. The sardine fishing, according to this latter authority, is carried on at sunrise and sunset, therefore in daylight, and the method is as follows. On arriving at the fishing ground the mast of the boat is lowered and the rudder unshipped, and two of the fishermen row the boat gently with two long oars. The captain pays out a single small-meshed net, about 30 yards long and 7 yards deep, and while it is attached to the boat he throws out on each side of the net handfuls of salted cod's roe, which is used as bait to attract the sardines. When the net is found to be loaded with fish, it is cast loose with a buoy attached to it, and another single net is shot in the same manner. When all the nets have been used they are again picked up and hauled on board. It will be seen that this method is quite different from that of the ordinary drift fishing practised in England, but the Frenchmen fish in the ordinary way for the larger sardines or pilchards which they catch in winter, using no bait in this case. In this winter fishing they use nets cured with cutch, and, therefore, brown, not green.

In the years 1898 and 1899 I obtained from France some of the nets used in the French sardine fishery. One of these, from Sables d'Olonne, a place a little to the south of the river Loire, had a mesh of 67 rows to the yard, and was of flax in its natural colour without any dye or curing substance. Another, from Cancarneau, a place further north, had a mesh of 54 rows to the yard, was also of flax, and was dyed a deep blue colour, apparently with some aniline dye, certainly not

with sulphate of copper. As the sardine nets are mostly made of flax, preservative treatment is not so necessary for them, but I presume that the soap and copper sulphate process is still used in France, at least in some of the centres of the sardine fishery.

With regard to the effect of the green colour on the visibility of the net in the water, I think there can be no doubt that a green or blue net is less visible than a brown in full daylight, but at night the green net seems more visible than the brown. In August 1899 I used a green net in the Cornish fashion from an ordinary pilchard boat near Falmouth. The green net was fastened to the end of the fleet of pilchard nets, and was shot at the outer end of the fleet. We hauled at 10 p.m. in bright moonlight, and the green net was very conspicuous at the top of the water and out of the water as we hauled. It caught, however, more pilchards than the other nets, but whether this was due to the green colour or the smaller mesh I could not say. The master of a Newlyn boat made a thorough trial of an ordinary mackerel net cured by me with soap and copper sulphate, and found it caught very few mackerel in comparison with the cutched nets. He believed the reason was that it was much more visible in the dark, especially on account of the 'briming' of the net in the water—that is, of the phosphorescence. At night, when the nets are illuminated by the small phosphorescent animals in the water which come in contact with them, it seems natural that a light-coloured net would show more against the dark surroundings than a dark-coloured cutch net. There is still a possibility, however, that the French method of fishing with green nets might be successful with nets

of the ordinary mesh, in the Cornish pilchard fishery in summer from July to the end of September, or even later. I did not make experiments on this particular point, as my object was to ascertain whether it was possible to catch pilchards of the same size as the French sardines—that is, from 5 in. to 7 in. long.

In conclusion, it will be desirable to give here a complete account of the experiments made with various methods of cure on separate pieces of net put into the water in Newlyn Harbour, as I have frequently referred to the results of these experiments.

The pieces were prepared as follows:—

1. Cutch alone; ½ lb. cutch boiled in ½ gallon water. The piece of net put into this till well soaked, then dried. Then put into cutch of same strength, steeped for two days and then dried.

2. Cutch and glue; ½ lb. glue dissolved in 1 gallon water. The net dipped into this, then squeezed and put into hot cutch—½ lb. cutch to ½ gallon water—then dried. Afterwards dipped a second time into cutch of same strength and dried again.

3. Cutch glue and bichromate of potash. The net was dipped into glue, 1 lb. to ½ gallon water, with a little bichromate of potash added; then put into cold cutch and left to steep two days.

4. Cutch and copper sulphate. The net was steeped two days in cutch, ½ lb. to ½ gallon water, then while wet put into copper sulphate, 1 lb. to ½ gallon water, and after a short soak rinsed in fresh water and dried.

5. Cutch and coal tar. The net was first saturated with coal tar, then squeezed and wrung out several times with hot water, then dried for a week, and

afterwards dipped in hot cutch, ½ lb. to ½ gallon water.

6. Cutch and coal tar mixed. ½ lb. cutch boiled in ½ gallon water, and then about a pint of coal tar stirred into the hot solution. The net was dipped into the hot mixture, then dried.

7. Cutch, tar, and green oil. The net was first steeped three days in cutch, ½ lb. to ½ gallon water. Then the same cutch was heated and the net passed hot from this through a mixture of coal tar, Stockholm tar, and green oil as thick as paint. The net was then passed through a wringing machine and dried.

8. Coal tar and green oil mixed. The net was steeped in the mixture, then passed through a wringing machine and hung up to dry.

9. Cutch and green oil. The net was steeped several days in cutch, ½ lb. to ½ gallon water, then dried and put into green oil, then passed through a wringing machine and hung up to dry.

10. Green oil alone. The net was simply saturated with green oil, passed through the wringer, and hung up to dry.

11. Cutch and Stockholm tar mixed. ½ lb. cutch boiled in half gallon water, and ½ pint Stockholm tar stirred into the hot solution, the net dipped into the mixture, squeezed out and dried.

12. Cutch, Stockholm tar, and green oil. The net was steeped three days in cutch, ½ lb. to ½ gallon water, then dried and soaked in Stockholm tar warmed, with a little turpentine added. As the net was very hard and sticky, it was soaked with green oil and passed through the wringing machine.

13. Cutch and linseed oil. The net was steeped in

cutch, ½ lb. to ½ gallon water, for three days, dried and then dipped in boiled oil, with driers added. After some weeks it was dipped again in hot cutch and dried.

14. Soap and copper sulphate. ½ lb. soap boiled in ½ gallon water, the net soaked in this and then put into a solution of copper sulphate, ½ lb. to ½ gallon water.

15. Soap, copper sulphate, and linseed oil. The net, prepared as in 14, was saturated with boiled oil, with driers added, and hung up to dry.

The pieces were all cut from the same mackerel net, 24½ rows to the yard, 12-ply, and the following table shows the results of testing:—

| Mode of Cure. | Strength when dry. lb. oz. | Strength after four weeks in water. lb. oz. | Strength after two months in water. lb. oz. |
|---|---|---|---|
| 1. Cutch only, two dips and steeped | 15 9 | 16 8 | 6 6 |
| 2. Glue and cutch: one dip in glue, two in cutch | 17 2 | 9 6 | ... |
| 3. Cutch glue and bichromate of potash | 16 11 | 14 4 | ... |
| 4. Cutch and copper sulphate | 13 8 | 10 9 | ... |
| 5. Cutch and coal tar, tarred first | 18 4 | 21 0 | 18 0 |
| 6. Cutch and coal tar mixed | 17 12 | 18 6 | 8 1 |
| 7. Cutch, tar, and green oil passed direct from the cutch into the tar | 17 3 | 18 0 | 14 3 |
| 8. Coal tar and green oil mixed | 16 0 | 16 1 | 14 12 |
| 9. Cutch and green oil | 15 14 | 18 4 | 17 0 |
| 10. Green oil alone | 16 5 | 16 0 | 15 8 |
| 11. Cutch and Stockholm tar mixed | 17 13 | 17 6 | 6 12 |
| 12. Cutch, Stockholm tar, and green oil | 14 4 | 18 0 | 16 6 |
| 13. Cutch and linseed oil | 15 1 | 16 12 | 15 8 |
| 14. Soap and copper sulphate | 15 1 | 15 8 | ... |
| 15. Soap, copper sulphate and linseed oil | 15 1 | 15 4 | 14 8 |

*Shrinkage of the mesh in net curing.*

There is one other point in connection with curing processes to which I have not yet referred, and that is the fact that cutch and other materials cause the cord of which the nets are made to shrink and shorten, and, therefore, make the mesh smaller. Cutch especially has this effect, and it is due to what is called the astringent property of tannins, but I have not yet met with a complete scientific explanation of the change produced in cotton or other fibre by astringent substances. It is possibly a chemical change connected with the removal of the elements of water from the substance of which the fibre is chemically composed. Cotton nets continue to shrink more or less every time they are barked, and allowance is made for this by ordering new nets of larger mesh than is required for the actual fishing, while old nets have so reduced a mesh that they are used for the smallest fish, or even sometimes may become useless from this cause before they are worn out.

The following table shows the measure of the mesh of the pieces of net in the above experiment after they had been one month in the harbour, the original measure being 24½ knots to the yard:—

| | Rows per yard. |
|---|---|
| 1. Cutch only | 26¼ |
| 2. Glue and cutch | 25½ |
| 3. Cutch, glue, and bichromate | 25½ |
| 4. Cutch and copper sulphate | 25½ |
| 5. Coal tar and cutch | 28½ |
| 6. Cutch and coal tar mixed | 27 |
| 7. Cutch tar and green oil | 25½ |
| 8. Coal tar and green oil | 25½ |

| | Rows per yard. |
|---|---|
| 9. Cutch and green oil . . . . | 26¼ |
| 10. Green oil alone. . . . . | 25½ |
| 11. Cutch and Stockholm tar . . . | 27 |
| 12. Cutch, Stockholm tar, and green oil . | 25½ |
| 13. Cutch and linseed oil . . . | 27 |
| 14. Soap and copper sulphate . . . | 27 |
| 15. Soap, copper sulphate, and linseed oil | 27 |

It appears from this that soap and copper sulphate shrink the mesh more than cutch, at least at the first curing. The mesh is, of course, smaller the greater number of rows of knots to the yard, the distance between two rows being a half mesh. The coal tar and cutch caused the greatest shrinkage, cutch and tar mixed together shrunk rather more than cutch alone, while in every case where green oil was used it decreased the shrinkage. For this reason green oil or creosote may be used with advantage on old nets which are much shrunken.

# APPENDIX

## DIRECTIONS FOR CURING NETS BY THE CUTCH AND BICHROMATE PROCESS

1. Cure the new net first with good cutch in the usual way. Two dips in cutch of ¾ lb. to the gallon are sufficient, but three dips should be given if the cutch is weak. The net to be dried after the first dip.

2. The bichromate is to be boiled in clean water, ¼ lb. bichromate to each gallon. The bichromate may be boiled in a cutch copper, provided that the copper is emptied and rinsed out with clean water first. On no account must any cutch be mixed with the bichromate.

3. Boil the bichromate until it is all dissolved, then draw it off into a clean tub or pan, then, while it is still hot, put the net into, or pass the net through it. The best way is to pass the net through, adding more hot bichromate from time to time, as the hotter and cleaner the bichromate solution is, the better it will act.

4. The bichromate solution will turn the cutched net nearly black. The net may then be dried or taken to sea and used at once.

5. After a new net has been thus cured, it should not be barked again till it has been used in fishing for five or six weeks, as too much barking makes the net too hard.

6. A new net may be cutched twice, then treated with bichromate, and taken to sea the same day, and will be found to be as well cured as other nets which have taken weeks to cure.

7. The bichromate should not be used more than once a year, or once at the beginning of a season. During a season the nets are to be barked—that is, cutched—in the usual way, but not so often. Old nets should have one dip in cutch before being passed through hot bichromate, as the bichromate is of no use without fresh cutch.

8. The cutched net may be passed through the hot bichromate directly after being cutched, only being wrung out first; or it may be dried and passed through the bichromate afterwards, provided the net be not put into the water between the cutching and the bichromating.

9. An ordinary barking trough may be used for the bichromate, provided that all the cutch liquor is removed, and the trough sluiced out with hot water. Similarly, after a boiler or trough has been used for bichromate it should be emptied and washed out before being used for cutch. A little staining of one with the other does not matter, but the bichromate and cutch must not be mixed in any quantity.

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| | |
|---|---|
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| Other Organic Matter ... | 13·22 |
| Mineral Matter ... ... | 1·34 |
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